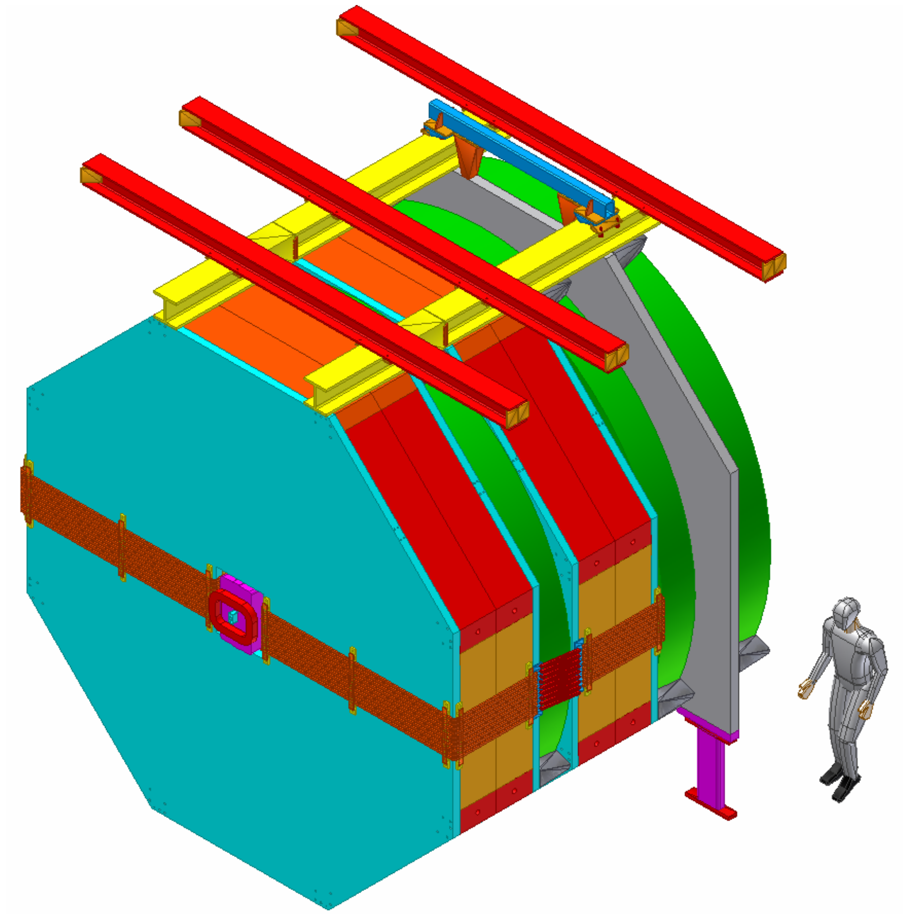
Muon System Overview

Paul Sheldon ~ Vanderbilt University



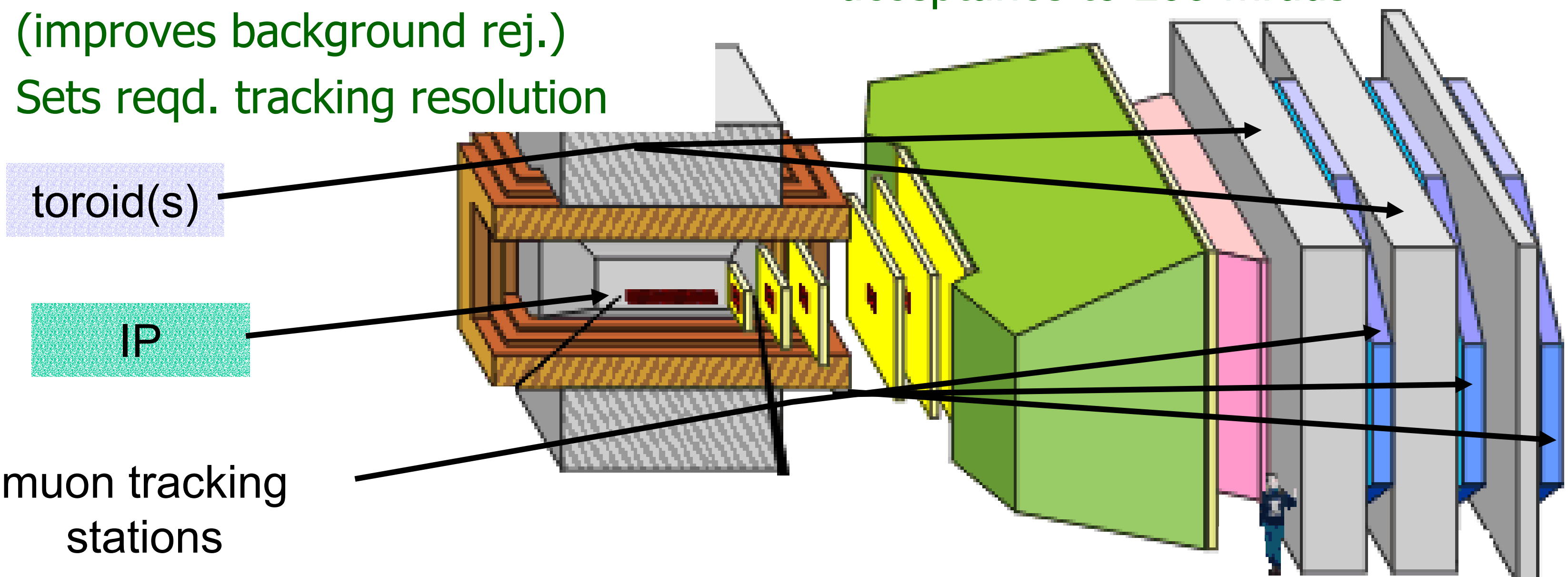
Institutions/People

- **Illinois**
  - Mats Selen
  - Jim Wiss
  - Doris Kim
  - Mike Haney
  - Vaidas Simaitas
- **Pavia**
  - Gianluigi Boca
- **Puerto Rico**
  - Angel Lopez
  - Hector Mendez
  - Eduardo Ramirez
  - Zhong Chao Li
  - Aldo Acosta
- **Vanderbilt**
  - Will Johns
  - Paul Sheldon
  - Med Webster
  - Eric Vaandering
  - John Fellenstein

Legend:
Engineer
Faculty
PostDoc
Technical

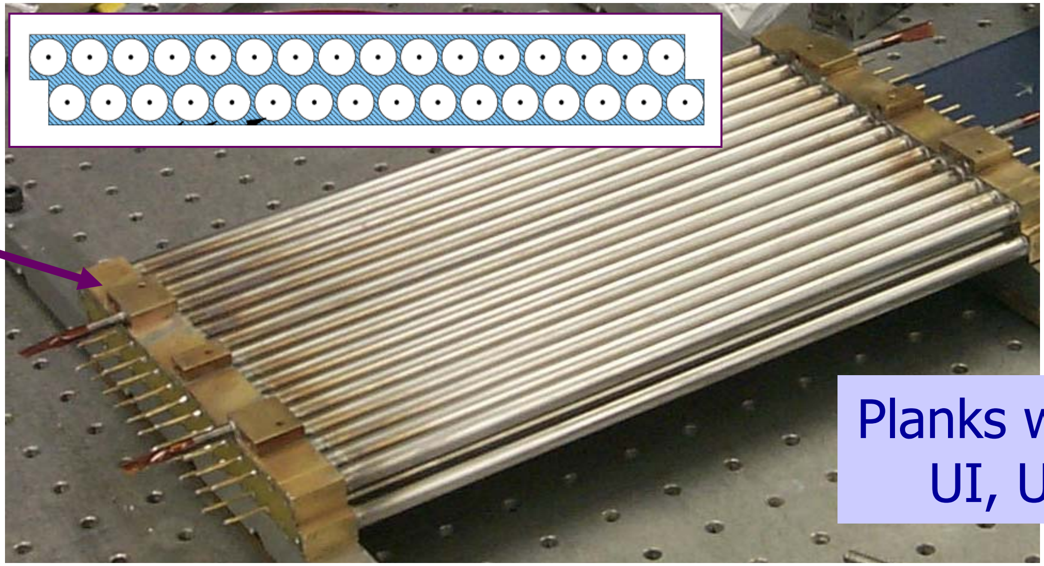
Goals & Constraints

- Provides Muon ID and Trigger
  - Trigger & ID for interesting physics states
  - Check/debug pixel trigger
- Fine-Grained tracking + toroids
  - Stand-alone mom./mass trig.
  - Momentum "confirmation" (improves background rej.)
  - Sets reqd. tracking resolution
- Other design goals/constraints:
  - Min. pattern recognition confusion
  - Minimize occupancy
  - Distribute occupancy uniformly
  - Minimize max. drift time
  - Robust, high-rate detector element
  - Size of hall limits wide-angle acceptance to 200 mrads



Basic Building Block: Plank

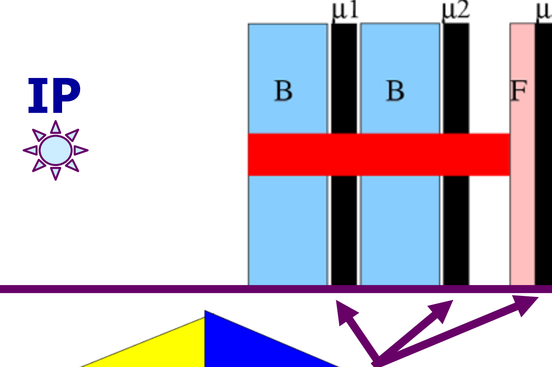
- Basic Building Block: Proportional Tube "Planks"
  - 3/8" diameter Stainless steel tubes (0.01" walls)
  - "picket fence" design
  - 30μ (diameter) gold-plated tungsten wire
  - Brass gas manifolds at each end (RF shielding important!)
  - Front-end electronics: use Penn ASDQ chips, modified CDF COT card
  - Likely to use 85% Ar - 15% CO_2 (no CF_4… more on this later)

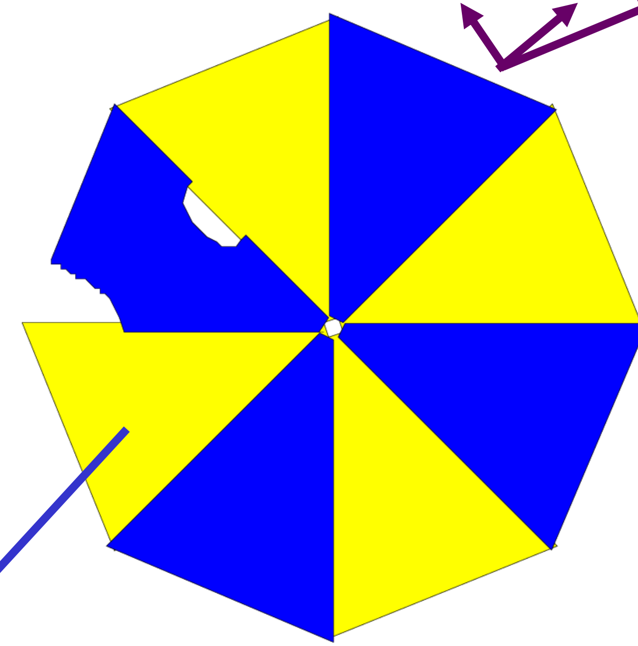


Planks will be built at UI, UPR, & Vand.

Geometry

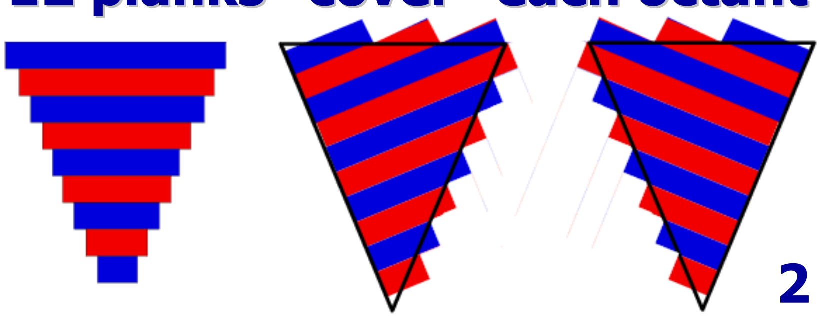
- Meets design goals/constraints:
  - Min. pattern recognition confusion
  - Reduce occupancy
  - Distribute occupancy uniformly
  - Minimize max. drift time
  - Robust, high-rate detector element
  - Stand-alone momentum/mass trigger
  - Momentum “confirmation” (improves background rejection)
  - Meets reqd. tracking resolution (<2mm)





Beams Eye View of each station:
overlapping ***octants***

12 planks “cover” each octant

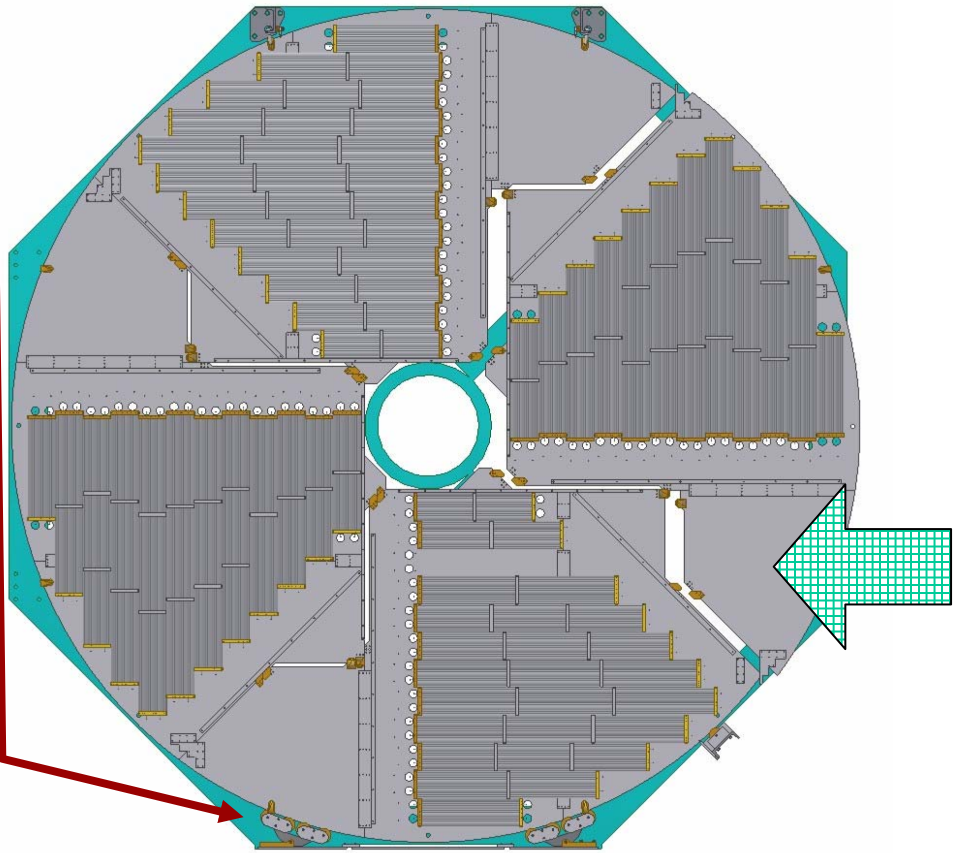


2 stereo views provide ϕ info.

4 views per station (r, u, v, r)

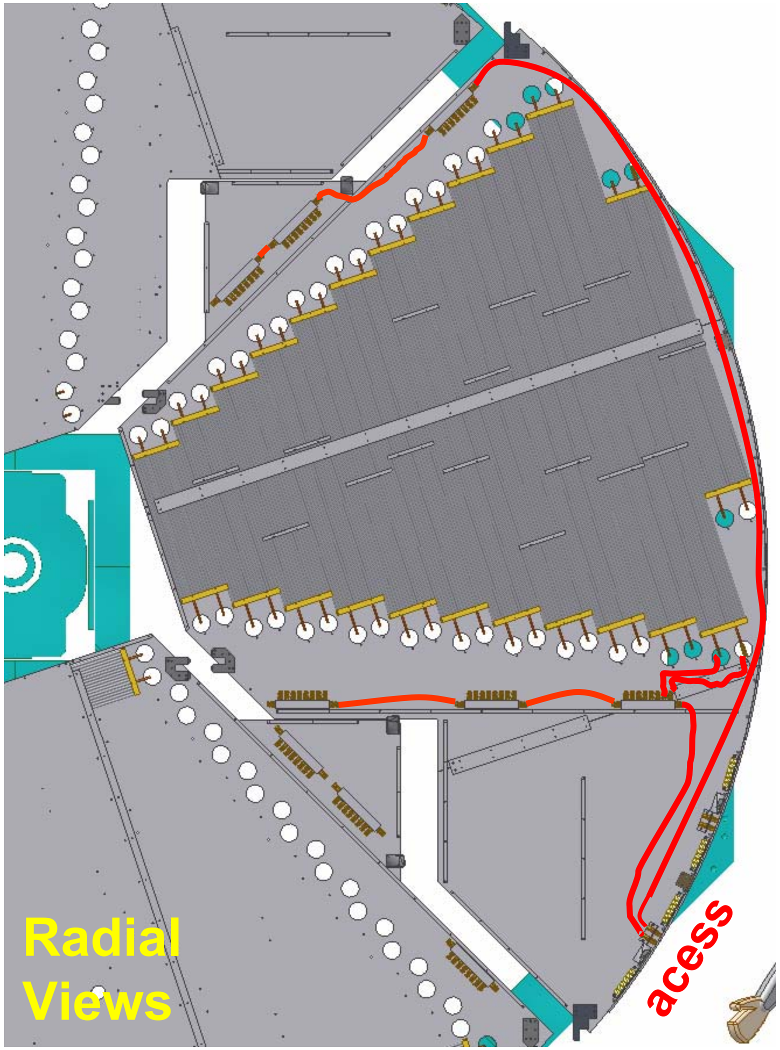
Installation Unit: Octant

- 4 ***octants*** make a wheel, two wheels construct a view.
- Octants will be built at institutions and delivered to FNAL.
- "Vertical Lazy Susan" installation - rotate during installation on floor rollers
- Each wheel will then be hung vertically from overhead beams.
- This allows each view to be individually serviced: it will be possible to install and/or remove an octant during run.
- Each octant is installed in wide aisle horizontally.



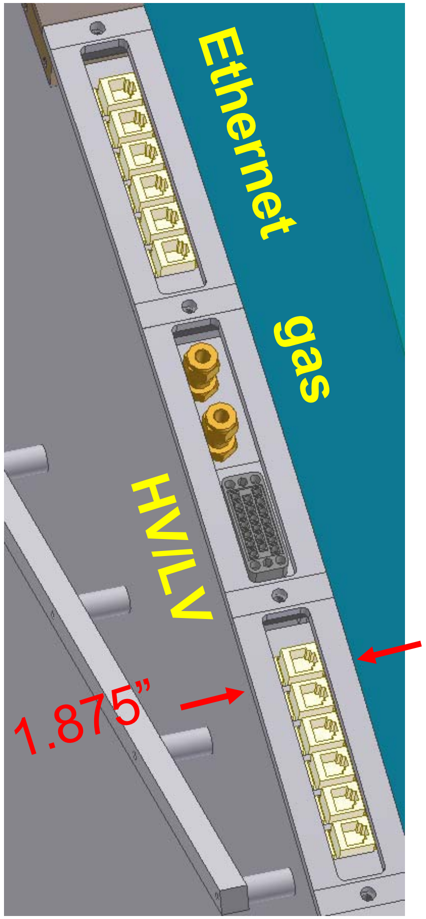
U - stereo wheel plates.

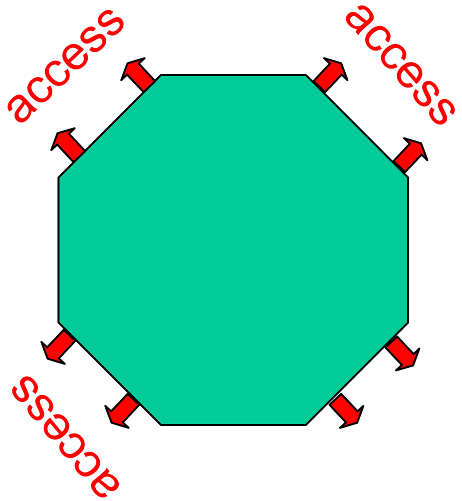
Gas/electronics access ports



This has the cover plate removed to show details.

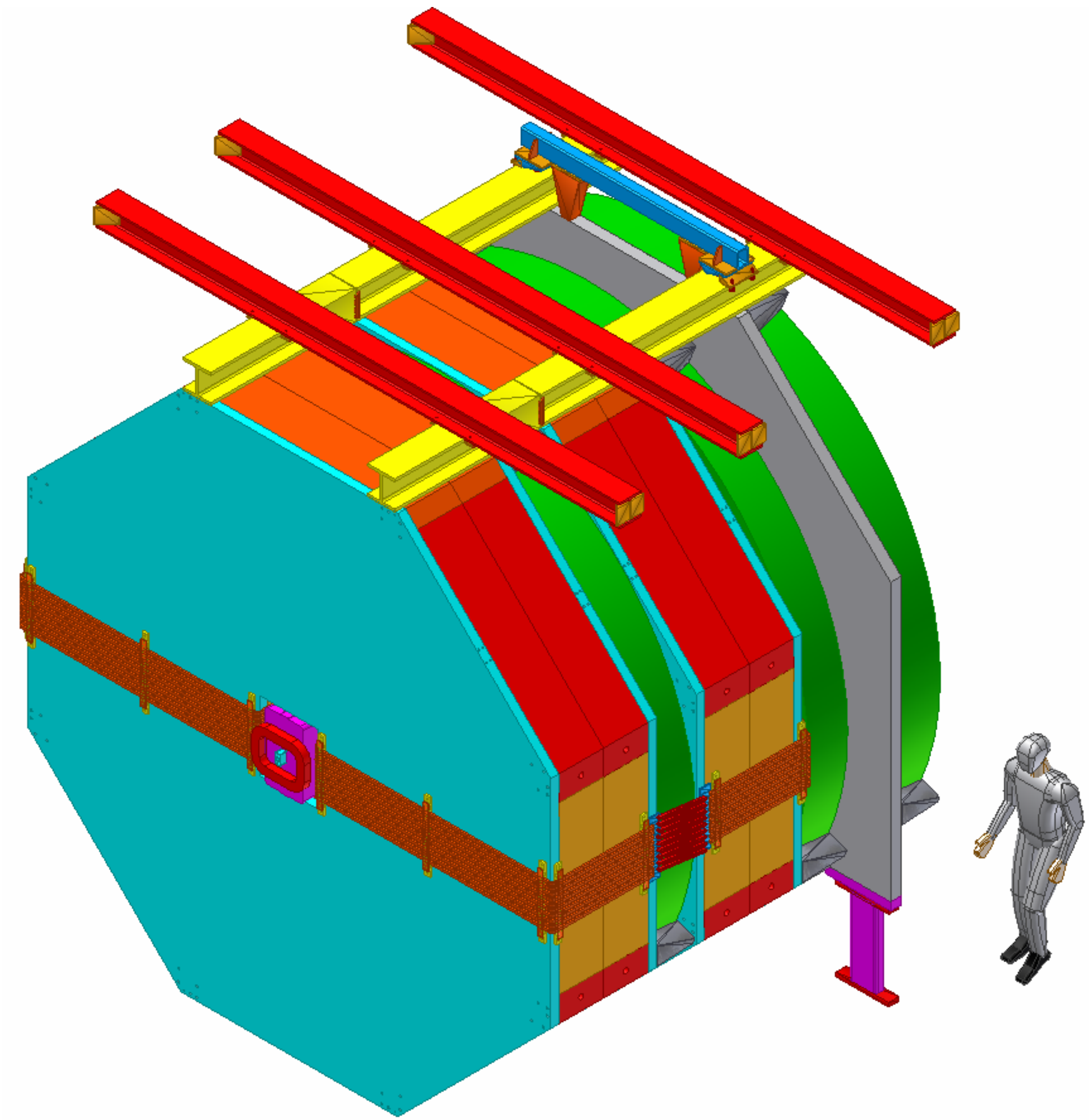
Access ports are through the "roller" band





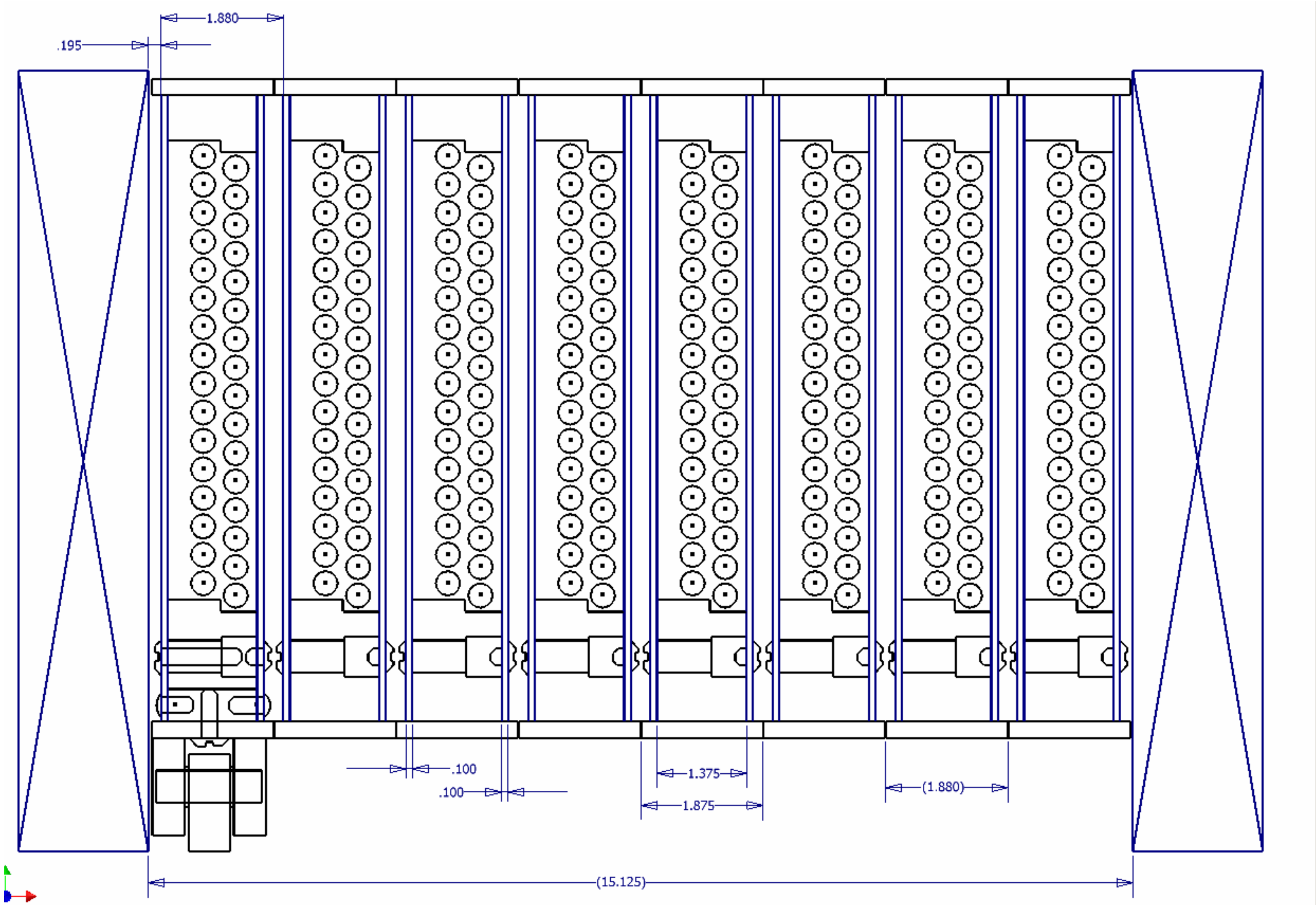
Top, bottom, and sides are <u>not</u> used for access panels

Overhead Support



- The entire muon system can move with the toroids since there are no floor connections.
- The plates are supported from individual floor rollers during installation and then hung vertically from the overhead beams.

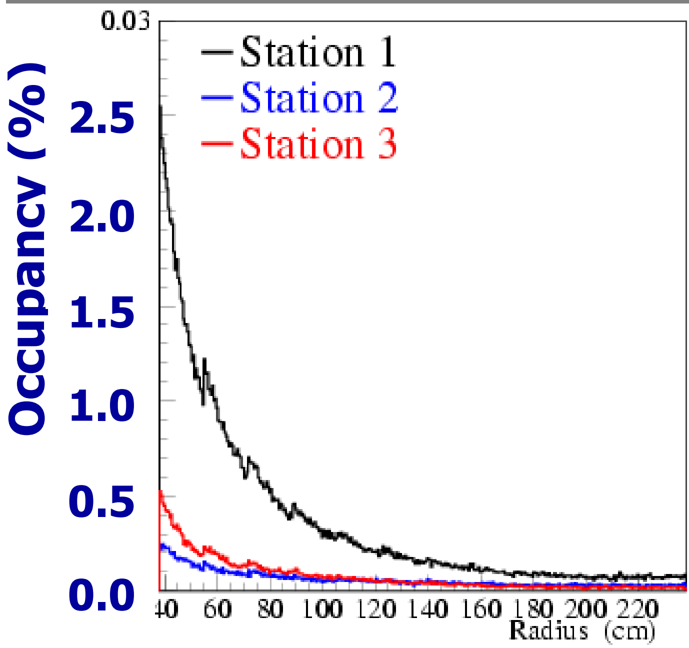
The Profile of a Station

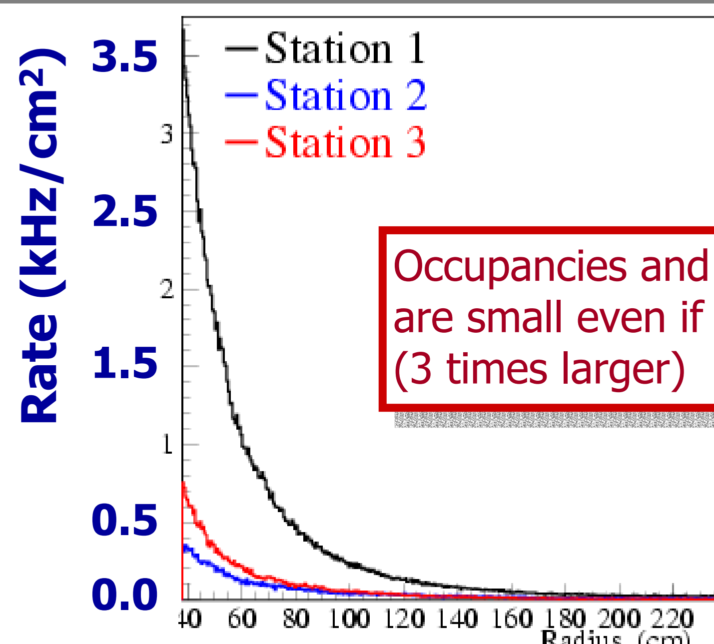


Expected Occupancies

- Minimum bias events will be largest source of hits in detector
- Generated assuming an average of 2 interactions/crossing
  - Luminosity of 2×10^{32} and 132 ns bunch spacing

What	Station 1	Station 2	Station 3	Total
avg. # of hits per crossing	42	8	9	54
avg. occupancy	0.34%	0.06%	0.07%	0.15%
max. channel occupancy	2.50%	0.24%	0.52%	
max. channel rate (kHz/cm^2)	3.7	0.4	0.8	

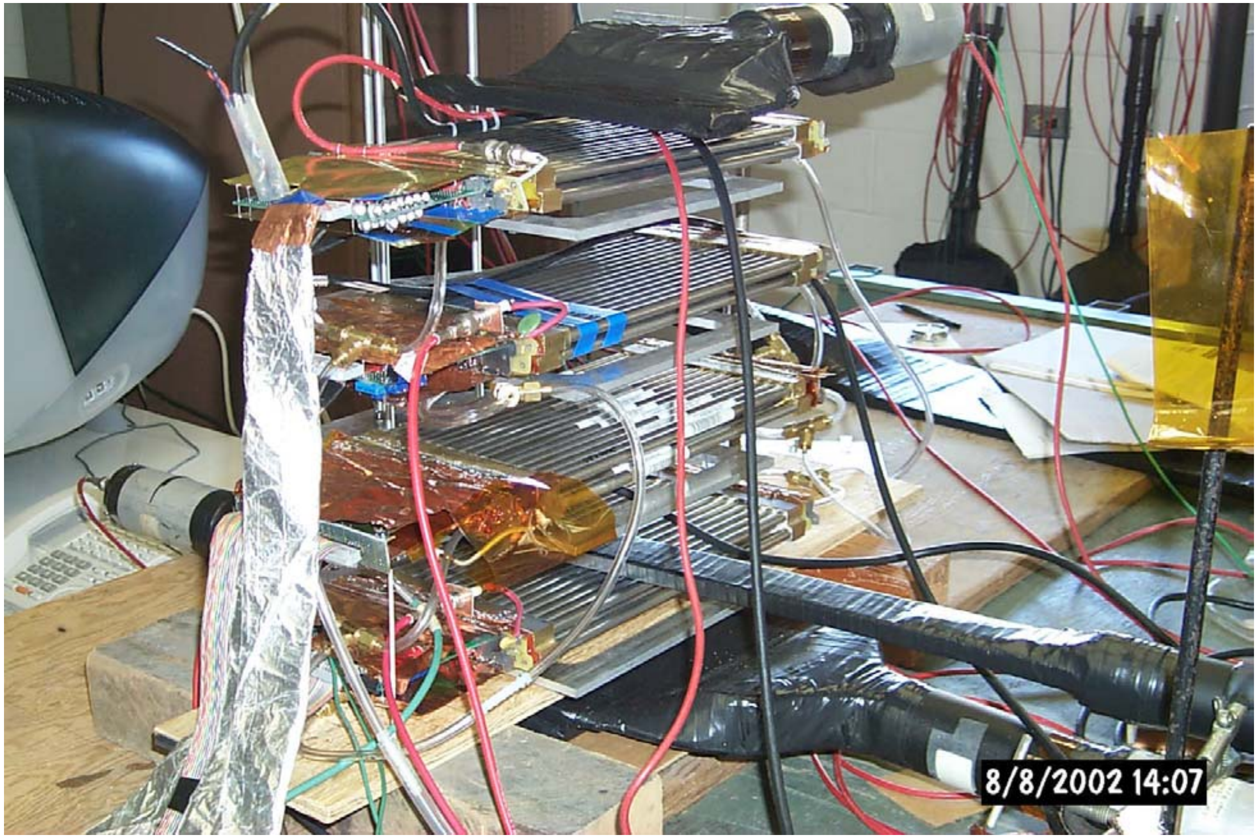




Occupancies and rates are small even if <n>=6 (3 times larger)

Plank & Gas Tests

- Cosmic ray test stand w/ 4 planks
- Noise level very near theoretical minimum (2 fC)
- Gas gains meas. w/ Fe55

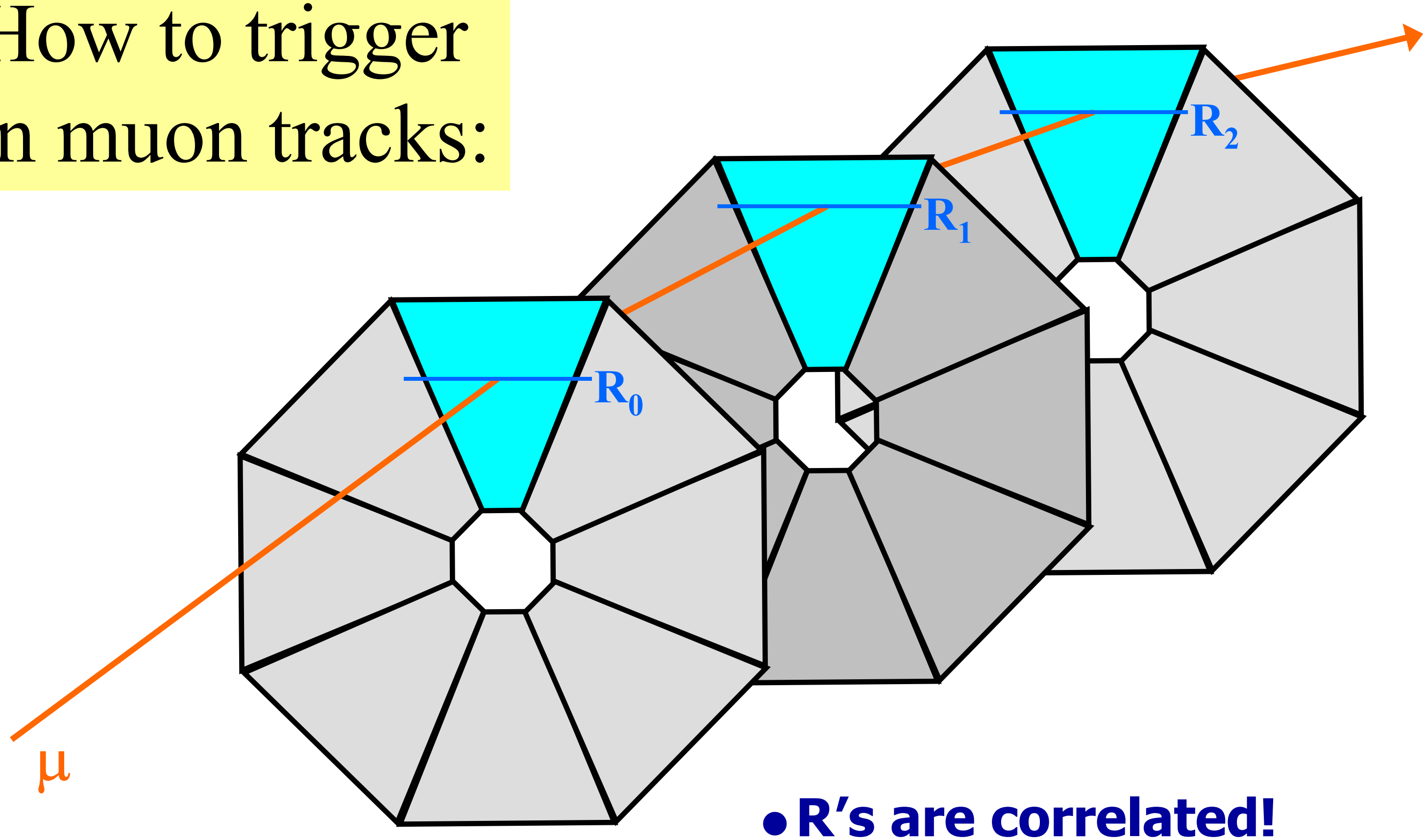


Aging

- Trying to be careful in design: all metal tubing for gas system, selection of other materials
- Will test all components for outgasing using a mass spectrograph
- Will monitor input gas during operation using a mass spectrograph
- "Safe" gases: only Argon and CO_2
- High Dose Test Planned

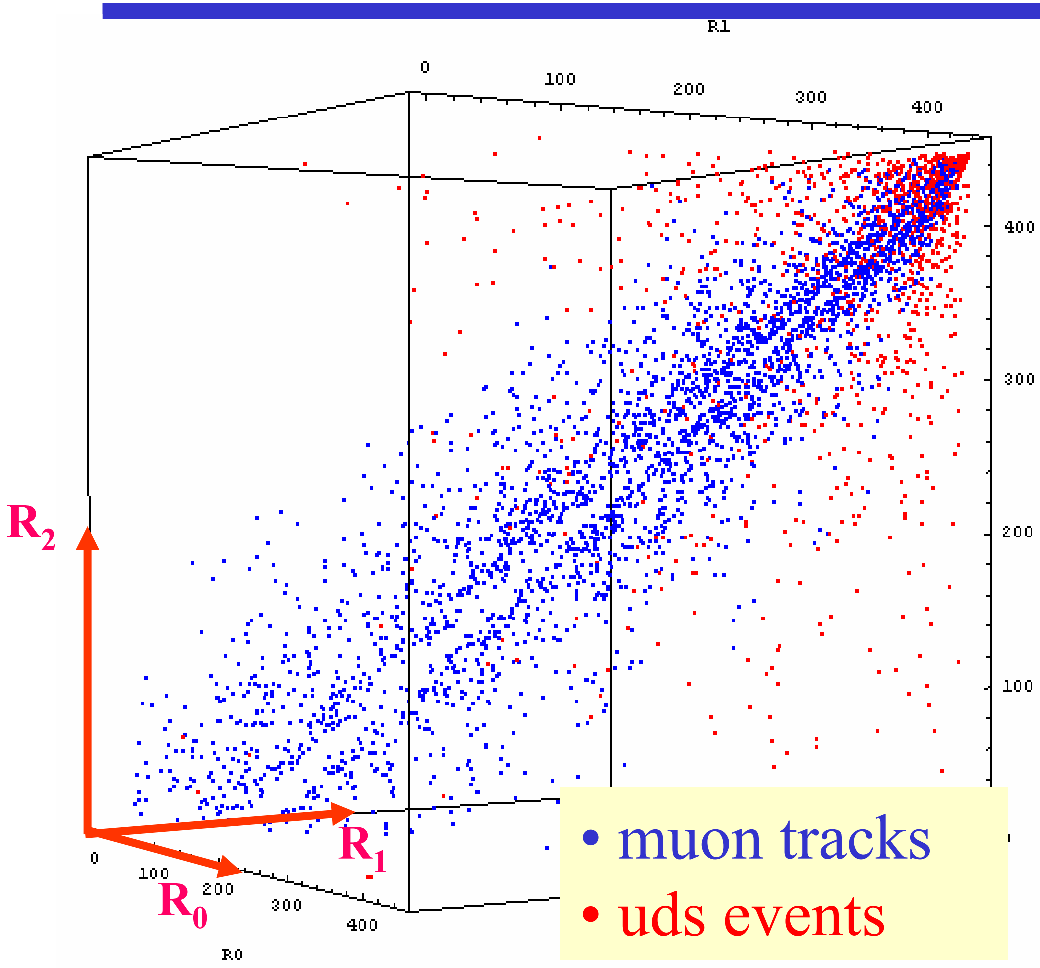
Trigger

How to trigger on muon tracks:



- **R's are correlated!**
- The same is true for ***U, V*** views…

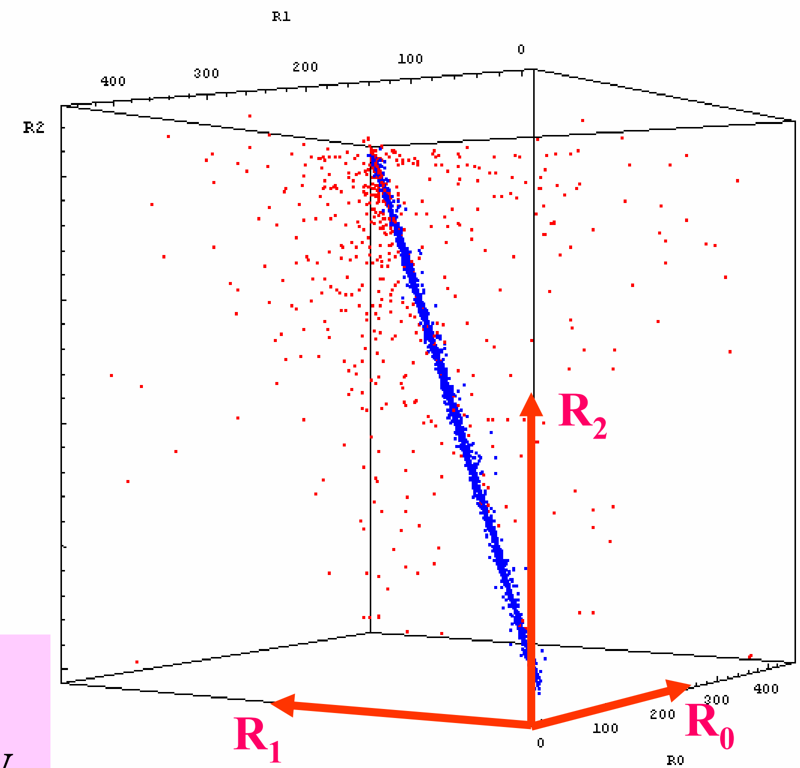
Distance-To-Plane Cut



Muon tracks line on a simple plane:

$R_2 = 27.69 - 1.26^*R_0 + 2.20^*R_1$

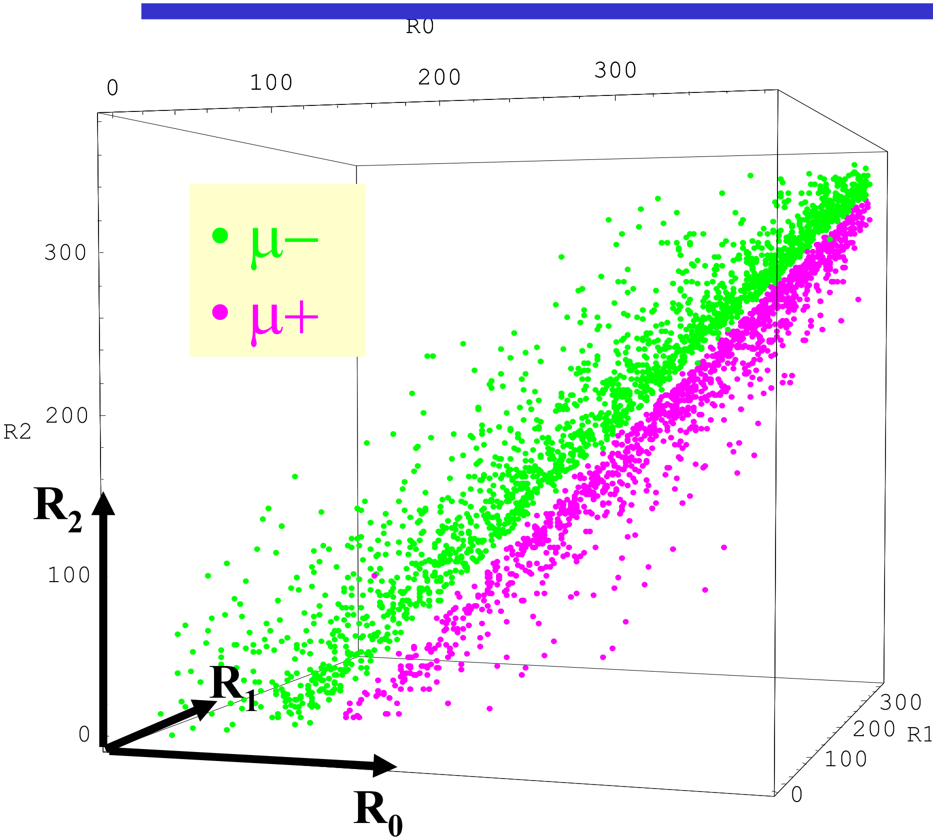
(R_0,R_1,R_2) in raw "tube numbers"



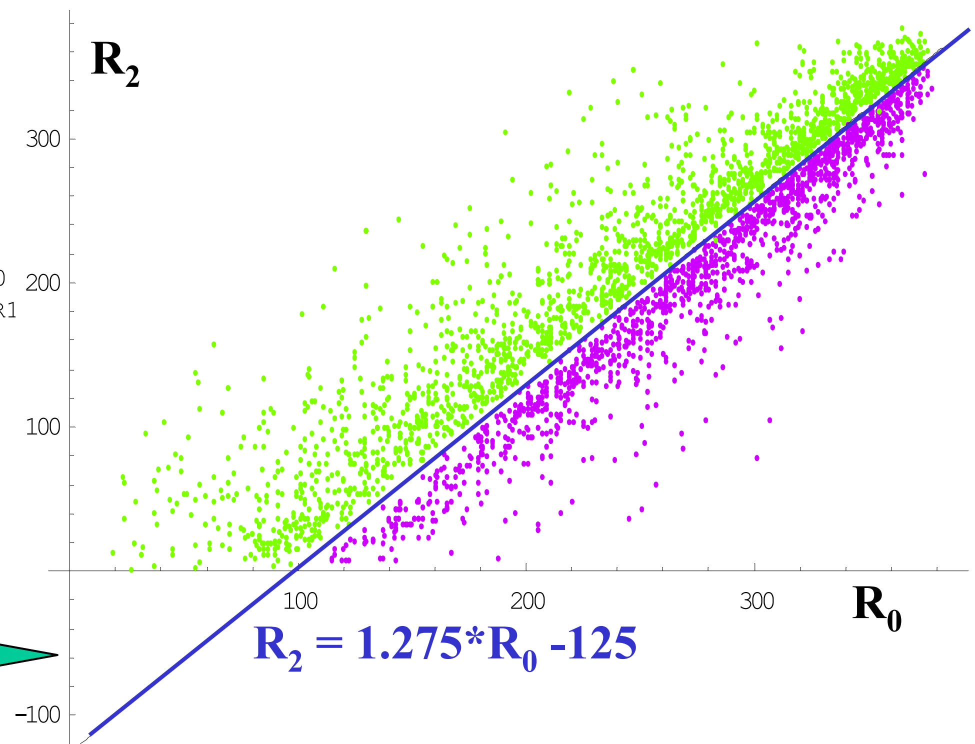
Strategy: Cut on closest distance to this plane for each crossing/octant/view.

Track Charge

Determining track charge is simple !



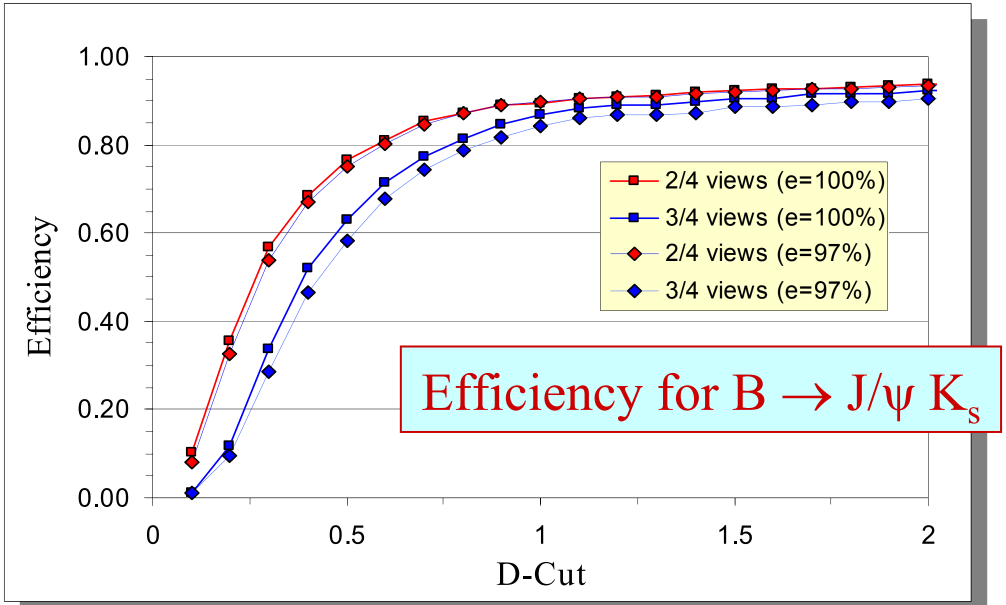
All we need to do is look at R_2 vs R_0.

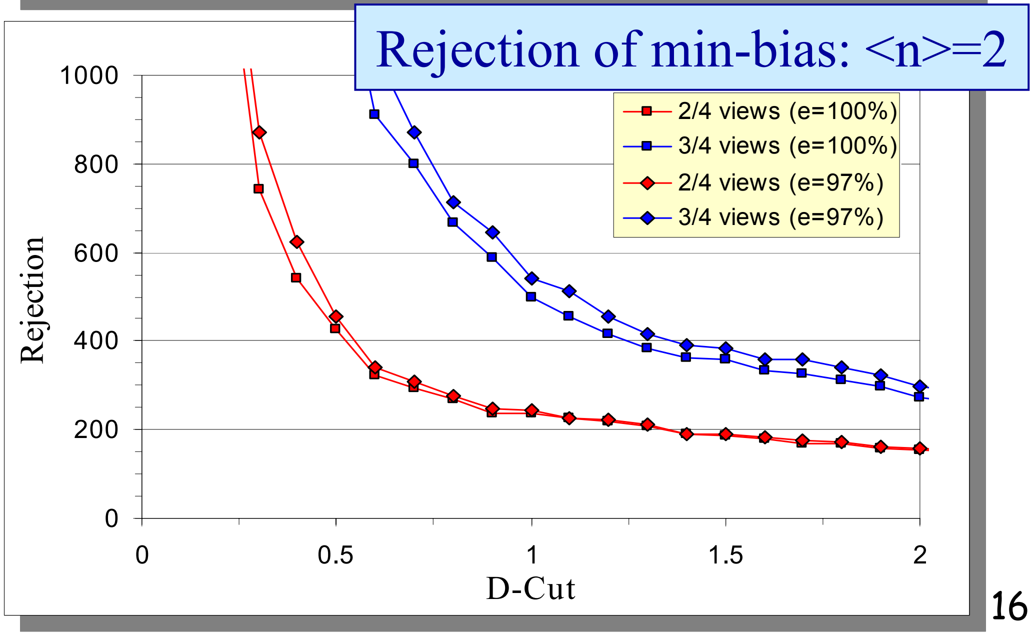


Di-Muon Trigger

BTeV GEANT Study

- D-cut: max. distance muon cand. can be out of plane
- Can also use “R” cut (ignore inner radii of system)
- >80% efficiency with rejection of >500
- What if backgrounds are worse? Try <n>=3,4,5
- Even with <n>=5, can still get ~60% efficiency with rejection of 500
- Trigger easy to implement in first level hardware





Muon SubProjects

WBS 1.5 – Muon
Paul Sheldon

1.5.1 Planks
Paul Sheldon

1.5.2 Detector Stations
Jim Wiss

1.5.3 Electronics
Will Johns

1.5.4 Test Stands
Will Johns

1.5.5 Gas System
Angel Lopez

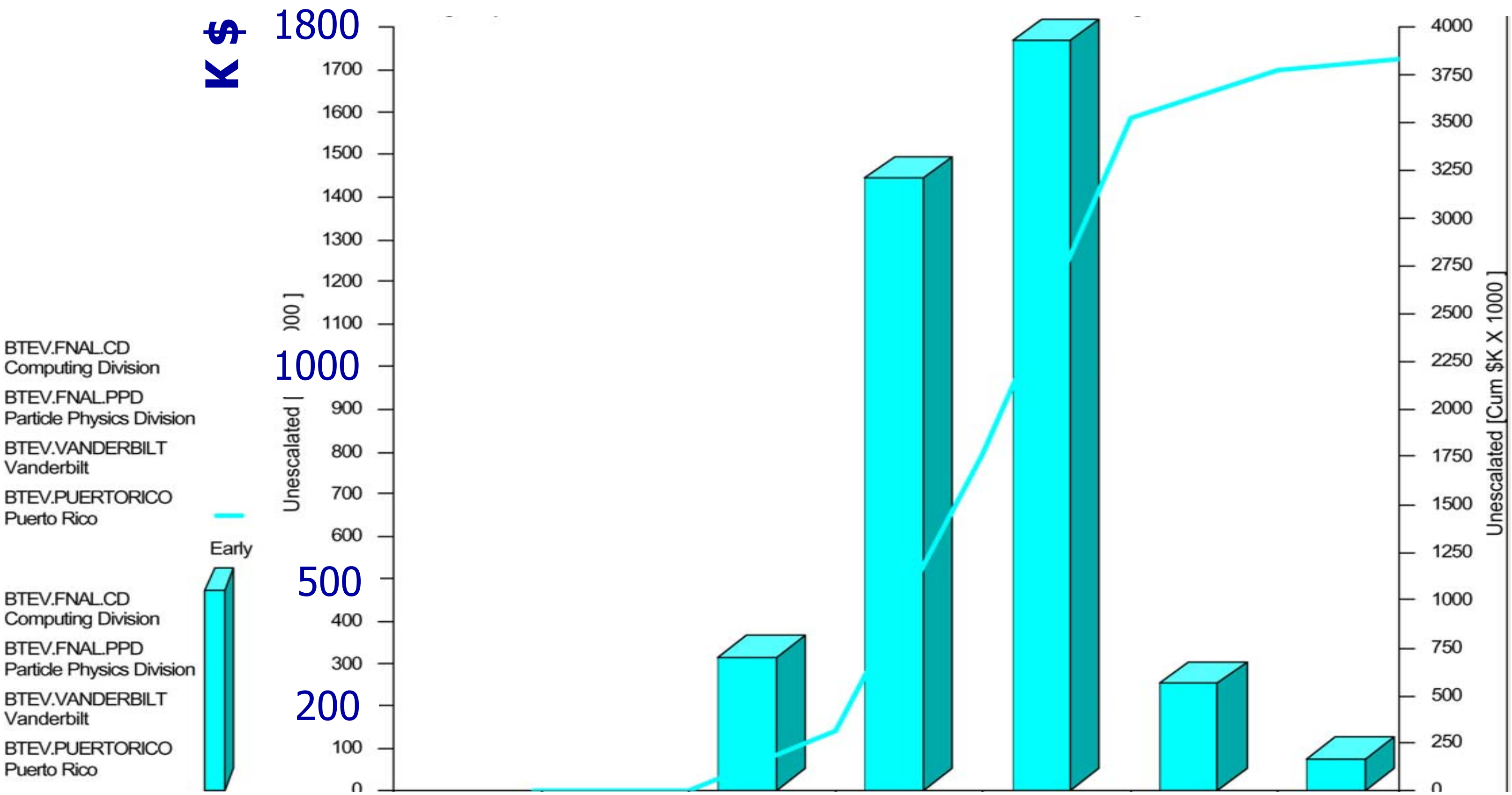
1.5.6 Software
Eduardo Ramirez

1.5.8 SubProject Mgmt

Muon Trigger
Selen/Haney

Muon Cost Profile

Base Cost (no contingency) by Fiscal Year



FY05	FY06	FY07	FY08	FY09	TOTAL
$317K	1477K	1807K	288K	74K	$4.0M

Muon Cost Profile

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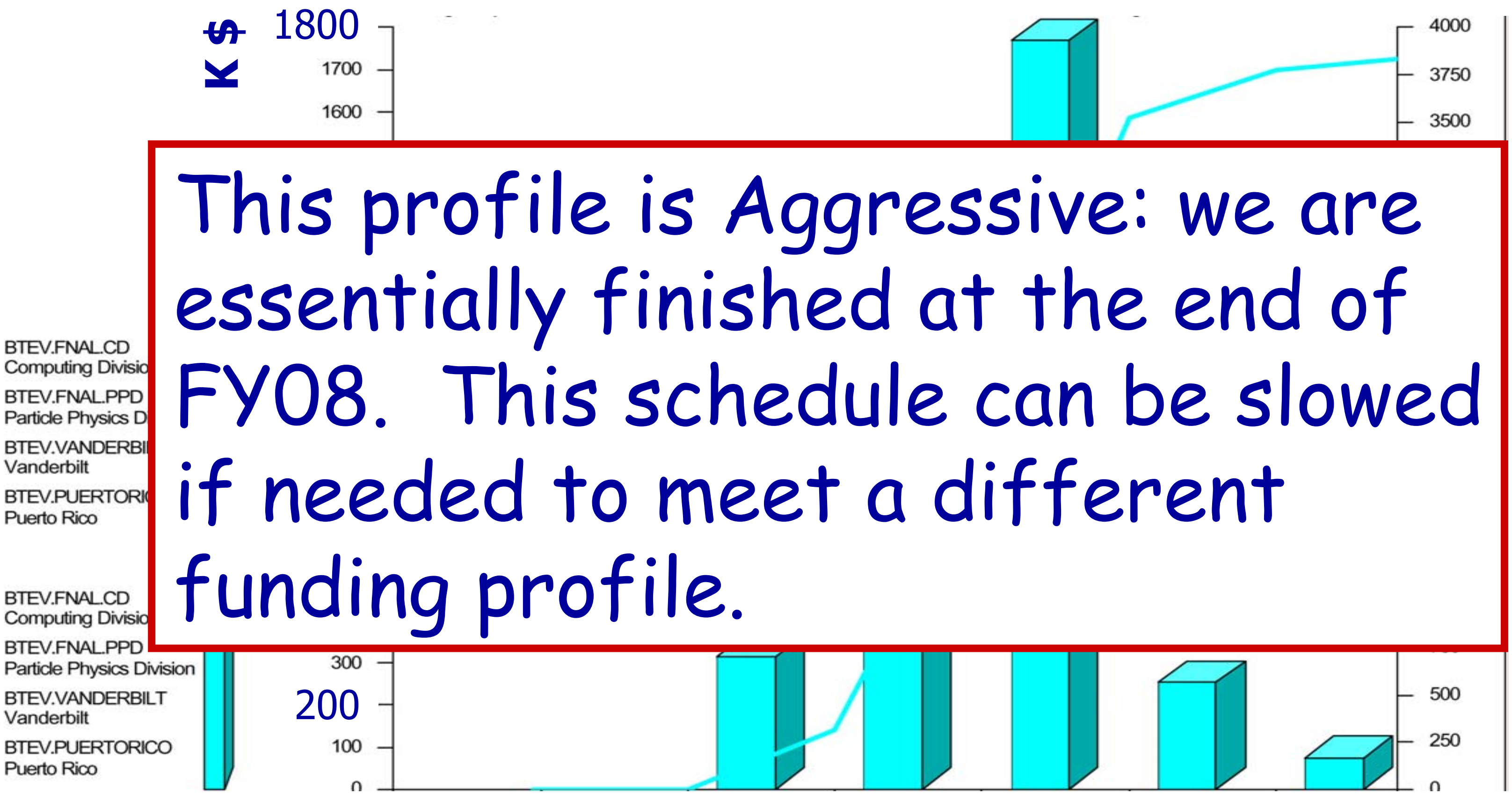
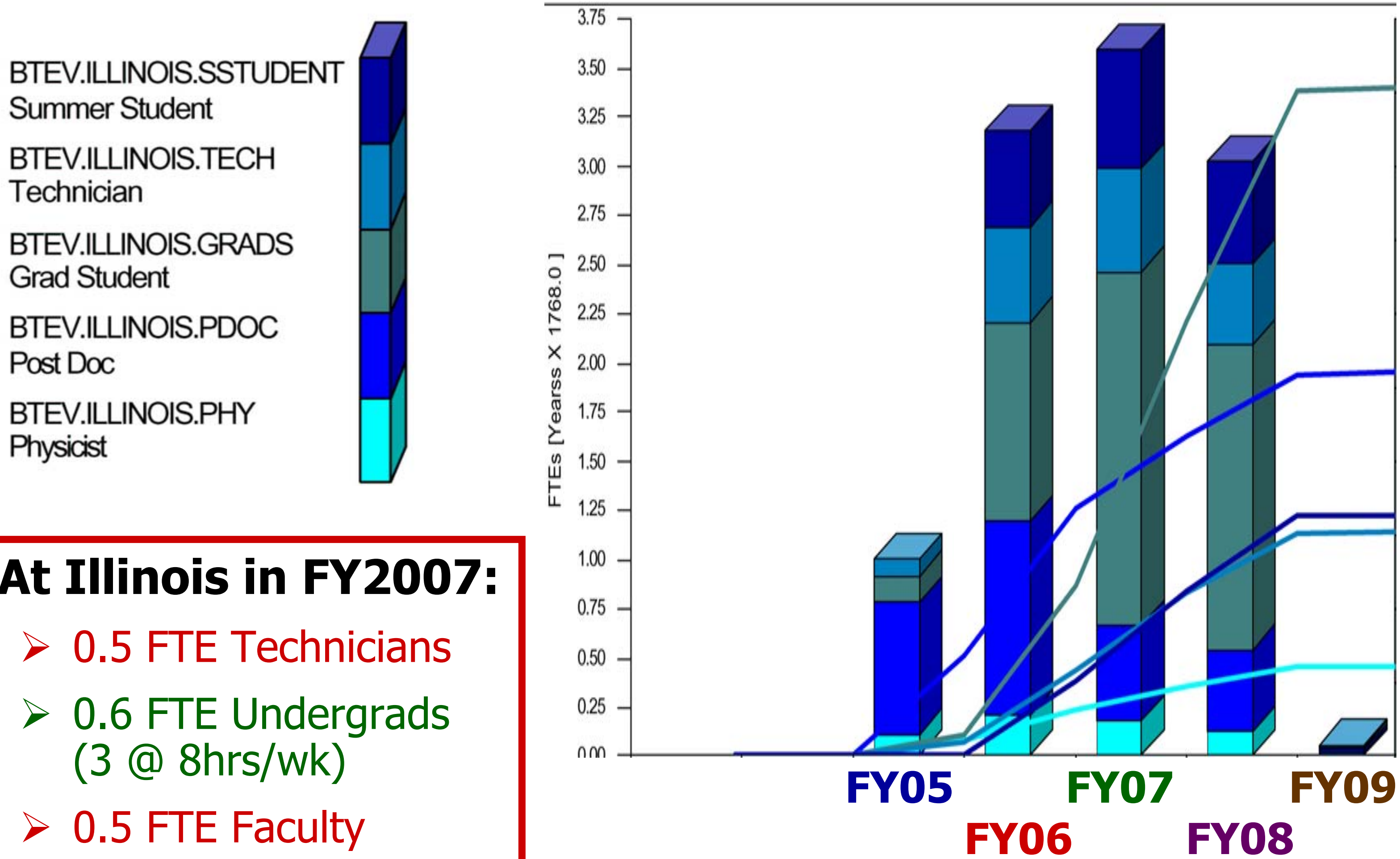


This profile is Aggressive: we are essentially finished at the end of FY08. This schedule can be slowed if needed to meet a different funding profile.

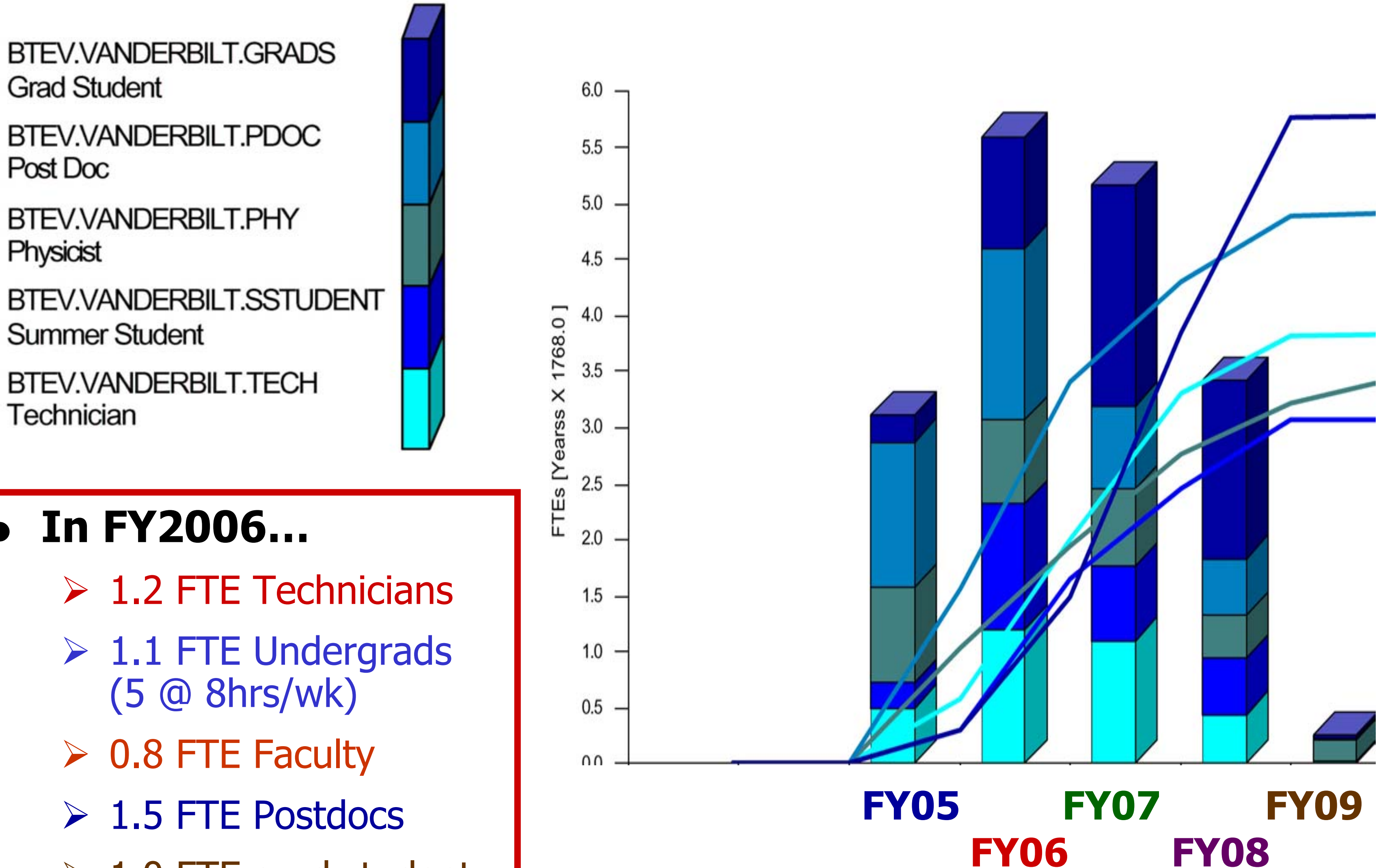
FY05	FY06	FY07	FY08	FY09	TOTAL
$317K	1477K	1807K	288K	74K	$4.0M

Labor at Institutions: Illinois



- **At Illinois in FY2007:**
  - 0.5 FTE Technicians
  - 0.6 FTE Undergrads (3 @ 8hrs/wk)
  - 0.5 FTE Faculty
  - 0.5 FTE Postdocs
  - 1.8 FTE grad students

Labor at Institutions: Vanderbilt

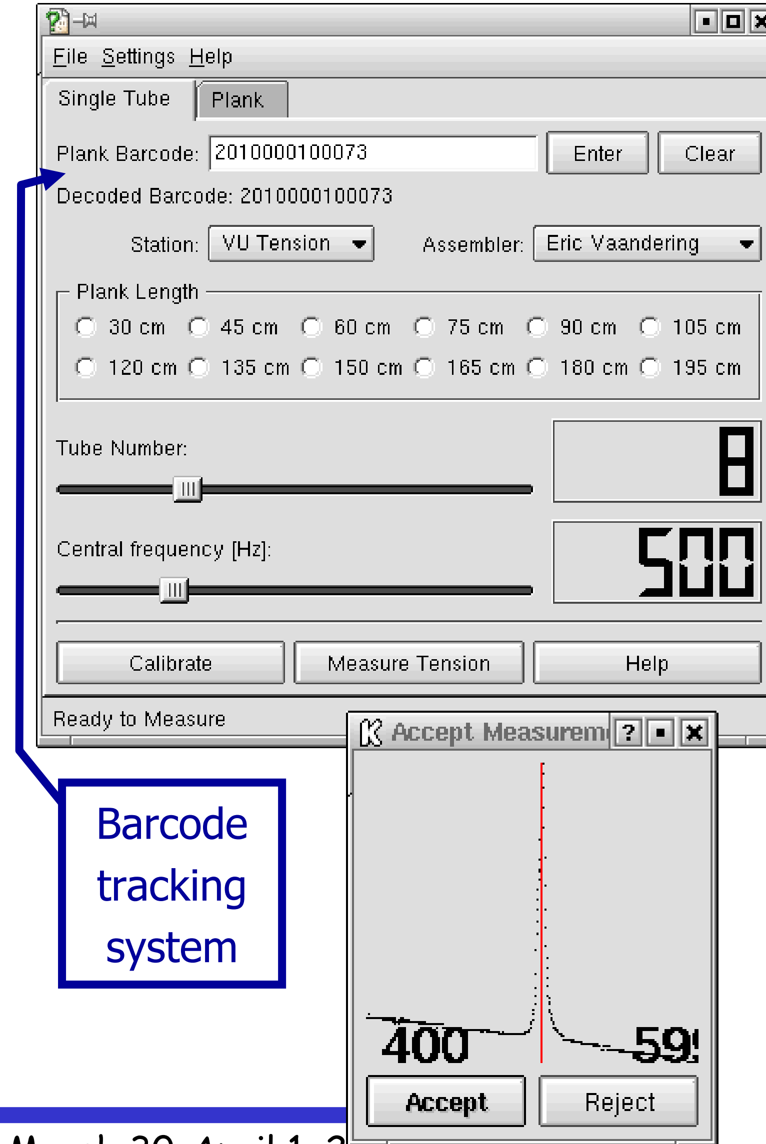


- **In FY2006…**
  - 1.2 FTE Technicians
  - 1.1 FTE Undergrads (5 @ 8hrs/wk)
  - 0.8 FTE Faculty
  - 1.5 FTE Postdocs
  - 1.0 FTE grad students

Significant Experience

- **We have significant experience w/ many of the steps necessary to build and install the muon system**
  - Built roughly 2 dozen planks, *with student labor*
  - Designed, built and used many of the test stands that we will use in our quality assurance program (tension measurement, etc.)
  - Built a 1/5 scale model of our full detector (including the toroids), using it to investigate support and installation issues
  - During the past year, significant engineering on mechanical support structure, now have a well-developed design
  - We have a well-developed design for the Front-End electronics and we have verified its properties with prototypes

Tension Test Stand



Comments from Previous Review

- Too many milestones
- Recommended work:
  - Finish WBS Dictionary
  - Linking of the WBS items to Basis of Estimate items
  - Review contingency estimates with BTeV management (reduce)
  - Participate in the BTeV Integration workshop
- We have been working on all of the above, and will complete all the above in the next two-three weeks. Our primary emphasis since the last review has been on getting our Open Plan WBS file into sufficient shape so that we can use it as a productive project management tool. We have been fixing the above items as a part of this effort.

Concluding Remarks

- We have dealt with many of the vendors we will use
  - Vanderbilt shop has fabricated the parts it has to make
  - Stainless tube vendors, …
  - Penn ASDQ's
- **The labor required is modest (43 FTEs) and well-matched to the size of the research groups already on-board.**
  - Physicist ("off-project") labor reqd is already present in our groups
  - student labor required is not larger than is typically present in each of our groups
- **We have chosen a robust, easy to build, well understood detector technology and our studies indicate that it is well matched to our problem.**
  - This includes a well-developed and engineered design for the mechanical structure and support